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(19)

(54) CONTROL APPARATUS FOR HOSPITAL BED MOTORS

(71) We, BORG-WARNER CORPORATION, a corporation duly organized and existing under and by virtue of the laws of the State of Delaware, United States of America, having its principal office and place of business at 200 South Michigan Avenue, Chicago, Illinois 60604, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to control apparatus for an electric motor and has particular application in beds of the type that comprise at least one movable panel which is arranged to be moved by an electric motor.

Hospital beds of the above type are conventionally adjusted in one or more manners, such as canting the head portion up and down or moving the knee portion up and down. Although originally moved by hand cranks, it has become increasingly popular to accomplish this movement by means of electric motors and linkages incorporated in the bed. These motors are commonly coupled to the available power mains for their energization. This motorizing of these beds not only saves human effort, but also allows the patient to control his bed's position directly from the bed, for example by means of a hand control unit, and lessens or eliminates the need for a nurse or other attendant to perform the task.

However, the coupling of electrical power to the hospital bed has introduced a new hazard — that of electrical shock and leakage currents.

A hospital patient is often more susceptible to electrical shock than the average individual. Not only is he in a weakened condition, but often he is attached to some sort of conductor. An intravenous bottle usually contains a fluid that is an electrolyte. Sometimes conductive catheters are inserted directly into the heart. In addition, various skin electrodes often are attached for test purposes.

Under any of these conditions, a slight leakage current can cause ventricular fibrillation (irregular contractions of the ventricles). The result can be heart failure.

The present invention is directed toward lowering or eliminating the danger to the patient of electric shock and leakage currents form the electric motor's control circuitry and provides control apparatus for a motor having a forward winding and a reverse winding, comprising two triacs each arranged to be connected in series with a respective one of the windings for directly connecting said windings to a power supply, a first voltage divider including a first photosensitive element coupled to a gate terminal of one of said triacs and arranged to normally apply to that gate terminal a voltage of an amplitude insufficient to render said triac conductive, a second voltage divider including a second photosensitive element coupled to a gate terminal of the other of said triacs and arranged to normally apply to that gate terminal a voltage of an amplitude insufficient to render said other triac conductive, first and second light sources each of which is optically coupled to, but electrically isolated from, a respective one of said first and second photosensitive elements, a control unit having first and second manually actuable switches each of which is arranged to connect one of said light sources to a source of voltage lower than the voltage of said power supply for energising said light sources, the first photosensitive device being arranged to receive light from the first light source to increase the amplitude of the voltage applied

to the gate terminal of said one triac to thereby render it conductive and cause rotation of the motor in a forward direction, the second photosensitive device being arranged to receive light from the second light source to increase the amplitude of the voltage applied to the gate terminal of the other of said triacs to thereby render it conductive and cause rotation of the motor in a reverse direction, and means operable when either one of the photosensitive elements is receiving light from its corresponding light source for ensuring that the triac controlled by the other of the photosensitive elements remains non-conductive.

In order that the invention be more clearly understood, embodiments thereof will now be described by way of example with reference to the accompanying drawings, in which: —

Figure 1 is a perspective view of a hospital bed in which the present invention is employed;

Figure 1A is an enlarged perspective view of a portion, the patient's hand control unit, of the bed of Figure 1;

Figure 2 is a circuit diagram, partly in block form, of the control and motor system for the bed of Figure 1; and,

Figure 3 is a circuit diagram of a modification of the control of Figure 2.

In Figure 1, the hospital bed, generally 10, has portions which are adjusted by linkages driven by electric motors which may be controlled from a patient's hand unit, generally 30, which is shown in more detail in Figure 1A. This unit may include, as shown, two sets of control pushbutton switches 32, 34 for raising and lowering the back and the knee portions of the bed 10.

As better shown in FIGURE 2, these switches 32 are connected in a low voltage circuit to an isolation circuit 50, to light one or the other of a pair of lamp bulbs 41, 42 of that circuit 50 which lamps are respectively optically coupled to photosensitive elements (photoresistors) 51, 52. The elements 51, 52 are connected to a solid-state power switching circuit 60 whose power handling switches (Triacs) 61, 62 are in series with the power mains and the directional coils 71, 72 of a motor 70 to control them.

A similar isolation circuit 50' and power switching circuit 60' are coupled to the "back" patient switch set 34 to control the "back" motor 70.

By depressing one or the other of the pushbuttons of set 32 one or the other of the lamps 41, 42 is lighted to cause the Triac 61 or 62 to connect power to one or the other of the coils 71, 72 and raise or lower the knee panel of the bed 10.

The provision of the optical coupling of circuit 50 effectively isolates the patient from the main power circuit and reduces or eliminates the possibilities of shock or leakage current therefrom. The solid-state circuit 60 eliminates power relays and the danger of a spark starting a fire in an oxygen atmosphere. With the solid-state control, the circuitry is intrinsically safe. Intrinsically safe is defined in this application as having insufficient electrical energy to ignite surgical cotton in an oxygen atmosphere.

The circuit 60 is tri-stable, it includes means for preventing the turning on of both triacs at the same time and also when desired allows neither to be energized. Power is connected to coil 71 through capacitor 73 when coil 72 is directly energized and vice versa.

Referring again to FIGURE 1, the bed 10, in more detail, includes a base 10B to which a bed lift frame 10F is attached by linkages 10L. The frame 10F has the conventional headboard 10HB and footboard 10FB attached to it.

The frame 10F supports a number of movable panels upon which a mattress (not shown) is placed. These include a back panel 11 hinged to pivot along 12, a knee panel 13 hinged to pivot along 14 and a foot panel 15 hinged to the knee panel 13 at 16.

The linkages for moving these panels and the motors 70, 70' of FIGURE 2 are hidden from view in FIGURE 1 under the panels but, as is the conventional practice these are mounted at and about the plane of the frame 10F. In addition to the control unit 30, a second unit 30' may be provided at the foot of the bed for operation by an attendant, and additional controls 30" also at the foot may be provided for, for example, raising and lowering the frame 10F by energizing the motor 10M and for cutting off the patient's unit 30.

The hand unit 30, as shown in FIGURE 1A, includes a pair of pushbuttons 32U and 32D for respectively raising up and lowering down the knee panel and a simple pair of pushbuttons 34U and 34D for similarly raising and lowering the back panel 11. The unit 30 is connected to the control circuitry 50 and 60 (FIGURE 2) by means of an insulated cable 30C.

The circuit arrangement for the pushbuttons 32 is shown in detail in FIGURE 2, it being understood that those for the pushbuttons 34 (and any additional controls desired) are similar.

The pushbutton switch 32U and 32D are shown in their normal or undepressed states (to which they are mechanically biased). It should be noted that the normally open contacts of each switch are in series with the NC (normally closed) contacts of the other so that if both are

depressed neither bulb 41 or bulb 42 is energized.

In the circuit of FIGURE 2 a low voltage supply for the unit 30 is derived from a transformer 40T which is part of a power supply generally designated 40. The transformer 40T has its primary coil connected across the a.c. mains 20A, 20C and includes two electrically separated secondary coils 40TL and 40TH which produce respectively lower and higher voltage a.c. outputs. The secondary 40TL has one side connected via line 43, an isolation resistor 53 and line 54 to one side of the lamp 41. The other side of the lamp 41 is connected via line 55 to one of the NO (normally open) contacts of the switch 32D. The other NO contact of this switch is connected to one NC contact of the switch 32U, whose other NC contact is connected via a line 44 to the other end of the low voltage coil 40TL. Thus pushing the switch 32D, with the switch 32U left unpushed, closes the circuit from the coil 40TL through the lamp 41 and lights that lamp.

A similar circuit from coil 40TL, through line 43, resistor 53, a line 56, through bulb 42, a line 57, the NC contacts and switch block of switch 32D, a line 33, the NO contacts of switch 32U and the line 44, allows the lamp 42 to be energized from the secondary 40TL when the pushbutton switch 32U is pushed to bridge its NO contacts while the switch 32D remains in its normal state bridging its NC contacts.

The lamps 41, 42 are, of course, light isolated from the opposite lamp's photoresistor 52, 51 as indicated by the wall segment 58.

The power switching circuit 60 includes additional means to prevent both the Up coil 72 and Down coil 71 of the motor 70 being directly connected to the power supply at the same time.

The secondary coil 40TH serves as part of a d.c. power supply which includes a diode 40D and a capacitor 40C which serves to develop a negative voltage on a line 46 relative to a reference potential line 47. This supply voltage is fed from line 46 to one side of each of the elements 51, 52. The other side of these elements 51 and 52 are respectively connected to electrical points 63, 64 of the power switching circuit 60. The point 63 is connected through resistor 65 to line 47, and through a resistor 67 to the base of a PNP transistor 67U. Similarly, the point 64 is connected through a resistor 66 to line 47, through a resistor 68 to the base of a PNP transistor 68D and in addition through a resistor 64L to the collector of the transistor 67U whose emitter is connected to line 47. Similarly, the collector of the transistor 68D is connected through a resistor 63L to point 63.

The collectors of the transistors 67U and 68D are respectively also connected to the control electrodes of the Triacs 62 and 61. The main terminal '1' and the main terminal '2' of the Triac 61 are respectively connected to the reference line 47 and to one side of the coil 71 of motor 70 while the main terminal '1' and '2' of the Triac 62 are similarly respectively connected to line 47 and one side of coil 72 of the motor 70.

The other ends of the coils 71 and 72 are connected together to the a.c. mains input 20A and a capacitor 73 is connected between the Triac connected ends of the coils 71, 72.

In operation, the pushing of one of the switches 32D (or 32U), without operating the other, serves to light the lamp 41 (or 42). This causes the light to fall on the photoresistor 51 (or 52) causing its resistance to drop. This fall in resistance in the voltage divider formed by resistors 51 and 65 (or 52 and 66) is reflected in a more negative potential at point 63 (or 64). This voltage is also communicated through the resistor 63L (or 64L) to drive the gate of the Triac 61 (or 62) more negative and cause it to conduct.

The drop in potential at point 63 (or 64) is coupled to the base of the transistor 67U (68U) through the resistor 67 (68) to turn on that tranistor. This effectively shorts the gate of Triac 62 (61) to its main terminal '1' and thus prevents its turning on.

Release of the pushbutton interrupts the circuit to the bulb and reverses the operation to de-energize the motor coil and stop the movement of the panel.

The operation of the additional controls and motor system such as that of the switch set 34, isolation circuit 50', power switching circuit 60' and motor 70', shown in FIGURE 2, may be identical with the low voltage supply being connected thereto via the line 44' and the line 43' and isolation resistor 53', while the d.c. power supply is connected thereto over the line 46'.

In FIGURE 3 a modification of the embodiment of FIGURES 1 and 2 is depicted in which the low voltage or step down transformer including the coil 40TL are eliminated and replaced by a battery 100 which may be a simple pen-torchbattery. In this embodiment current limiting resistors 153, 153', similar to the resistors 53, 53 are connected between the battery 100 in the hand unit 30 rather than at the bulbs in the circuit 50. In this case the line 144 (similar to the line 44 of FIGURE 2) need only be connected to the lines 54 and

56. Otherwise the circuit of FIGURE 2 is unchanged and its operation would be substantially the same as described above.

WHAT WE CLAIM IS:

1. Control apparatus for a motor having a forward winding and a reverse winding, comprising two triacs each arranged to be connected in series with a respective one of the windings for directly connecting said windings to a power supply, a first voltage divider including a first photosensitive element coupled to a gate terminal of one of said triacs and arranged to normally apply to that gate terminal a voltage of an amplitude insufficient to render said triac conductive, a second voltage divider including a second photosensitive element coupled to a gate terminal of the other of said triacs and arranged to normally apply to that gate terminal a voltage of an amplitude insufficient to render said other triac conductive, first and second light sources each of which is optically coupled to, but electrically isolated from, a respective one of said first and second photosensitive elements, a control unit having first and second manually actuable switches each of which is arranged to connect one of said light sources to a source of voltage lower than the voltage of said power supply for energising said light sources the first photosensitive device being arranged to receive light from the first light source to increase the amplitude of the voltage applied to the gate terminal of said one triac to thereby render it conductive and cause rotation of the motor in a forward direction, the second photosensitive device being arranged to receive light from the second light source to increase the amplitude of the voltage applied to the gate terminal of the other of said triacs to thereby render it conductive and cause rotation of the motor in a reverse direction, and means operable when either one of the photosensitive elements is receiving light from its corresponding light source for ensuring that the triac controlled by the other of the photosensitive elements remains non-conductive.

2. An adjustable bed of the type having at least one panel movable by an electric motor which has control apparatus as claimed in claim 1.

3. Control apparatus for a motor substantially as hereinbefore described with reference to Figures 1A and 2 or Figures 1A and 2 as modified by Figure 3 of the accompanying drawings.

4. An adjustable bed substantially as hereinbefore described with reference to Figures 1, 1A and 2 or Figures 1, 1A, and 2 as modified by Figure 3 of the accompanying drawings.

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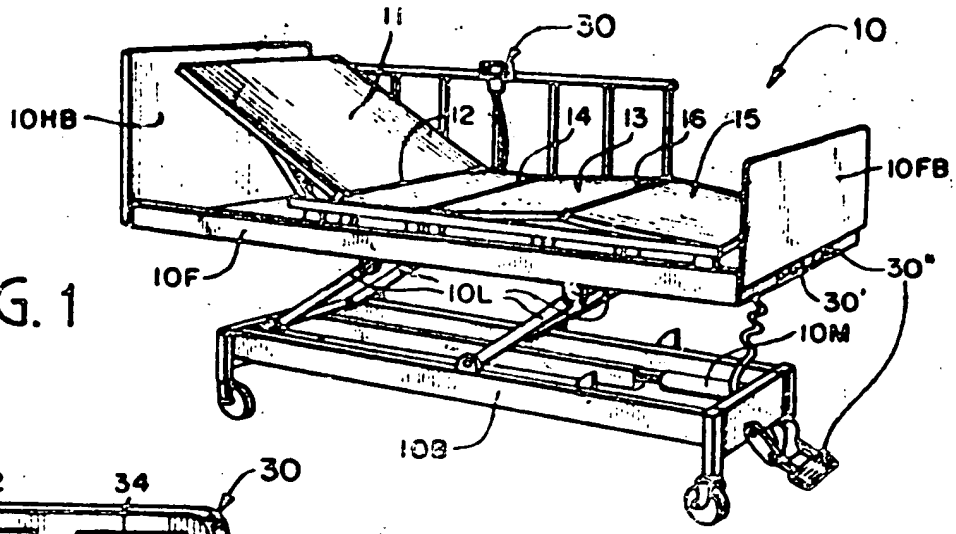


FIG. 1

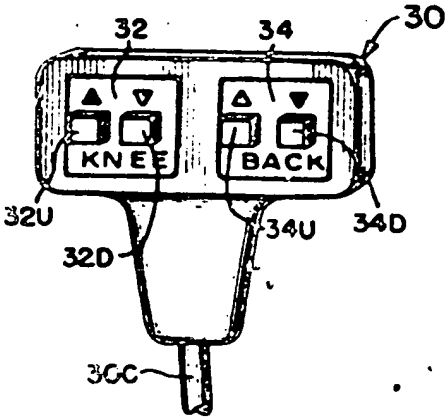


FIG. 1A

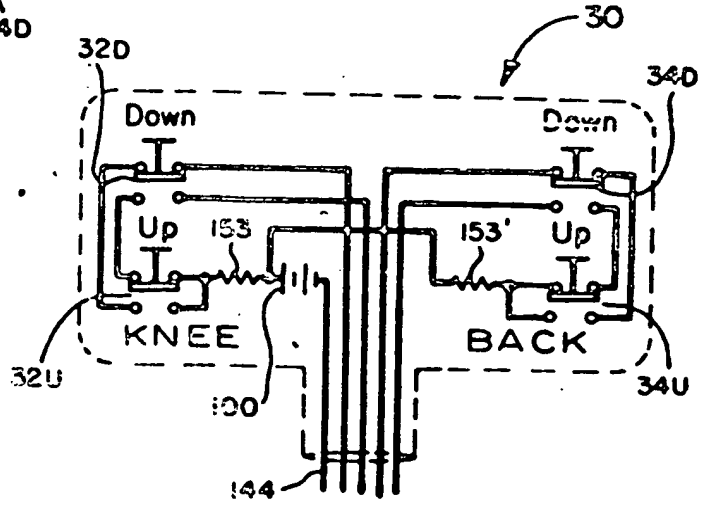
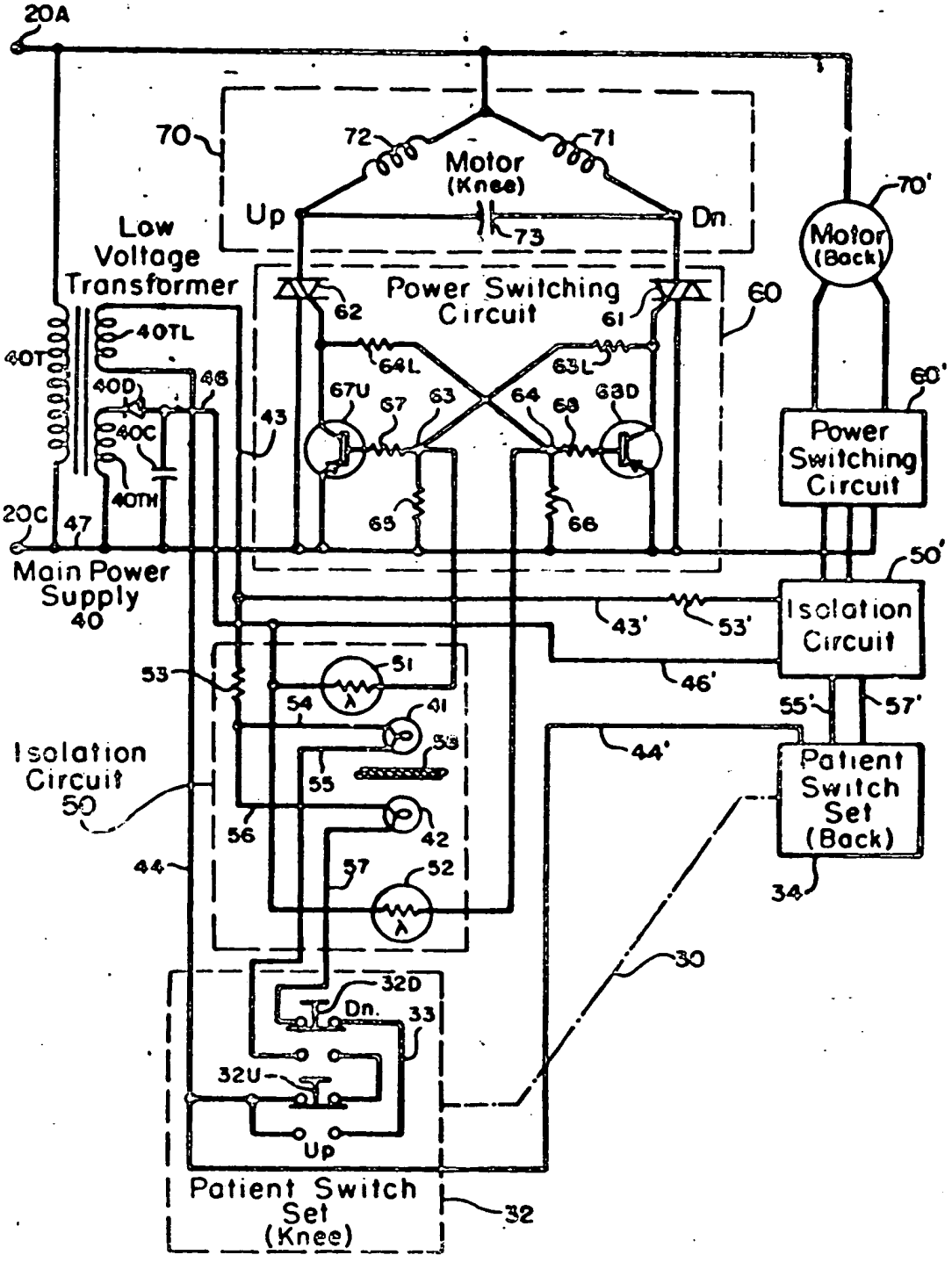


FIG. 3

FIG. 2


20A
70
72
71
Motor (Knee)
Up
Dn
73
70'
Motor (Back)
Low Voltage Transformer
Power Switching Circuit
62
61
60
40T
40TL
40D
40C
40TH
46
43
64L
63L
67U
67
63
64
68
63D
65
66
60'
Power Switching Circuit
20C
47
Main Power Supply 40
50'
Isolation Circuit
43'
53'
46'
53
51
54
41
55
56
42
44
57
52
55'
57'
44'
Isolation Circuit 50
Patient Switch Set (Back)
34
30
32D
Dn.
33
32U
Up
Patient Switch Set (Knee)
32